

**368 11001**

**BELLCOMM, INC.**

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**SUBJECT:** A Review of the Block II CM/SM  
Modifications Required for AAP -  
Case 620

**DATE:** November 1, 1968  
**FROM:** J. J. Gabrik

MEMORANDUM FOR FILE

This memorandum reviews the Block II spacecraft subsystem modifications proposed for AAP and the requirements which generated the modifications. The primary source of data used for the review was the North American Rockwell baseline configuration document SD 68-555A and the minutes from the CM/SM baseline configuration review held at MSC October 14-17.

Of the twenty-six Block II spacecraft subsystems eighteen require modifications for AAP. Ten of the subsystems require major modifications and the others only minor modifications most of which are because of secondary effects (see Table I). All of the modifications identified are to satisfy engineering or mission operation requirements. The AAP spacecraft delta requirements and resulting subsystem modifications result from longer mission duration, increased mission support, docked attitude constraints and a desire to save cost and weight. The primary spacecraft changes related to these mission requirements are summarized in Table II. A detailed listing of the AAP and Block II delta requirements and resulting modifications are contained in the attachment.

The Service Module (SM) modifications are more extensive than those in the Command Module (CM). For comparison purposes the percent of hardware weight change was extracted from the weight report. The CM hardware changes identified amount to less than two percent by weight while the SM changes will amount to approximately fifty percent of the dry weight.

1024-JJG-li

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Attachments

(NASA-CR-100243) A REVIEW OF THE BLOCK 2  
CM/SM MODIFICATIONS REQUIRED FOR AAP - CASE  
620 (Bellcomm, Inc.) 14 P

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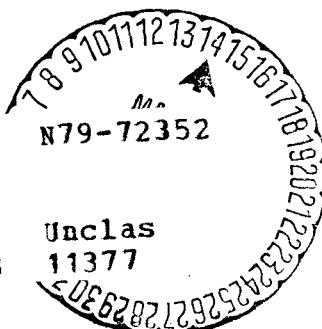


TABLE I  
BLOCK II SUBSYSTEMS MODIFIED FOR AAP

Subsystem	Major Mod	Minor Mod	Remarks
1. EPS - Electrical Power Subsystem	X		Change fuel cells
2. CSS - Cryogenic Storage Subsystem	X		Change cryo tanks
3. ECS - Environmental Control Subsystem	X		Two gas atmosphere, replumb radiators
4. TCS - Thermal Control Subsystem	X		Insulation, heaters, blankets
5. SECS - Sequence Events Control Subsystem		X	Secondary effects
6. Pyro - Pyrotechnic		X	Secondary effects
7. LV EDS - Launch Vehicle Emergency Detection Subsystem		X	AAP uses Saturn I rather than Saturn V
8. PNGS - Primary Navigation & Guidance Subsystem	X		Add Command capability for unmanned rendezvous of LM/ATM
9. SPS - Service Propulsion Subsystem	X		Remove storage tanks
10. SM RCS - SM Reaction Control Subsystem	X		Add 2400 lbs of propellant capability
11. CS - Communication Subsystem	X		Add X-miters for command capability for unmanned rendezvous of LM/ATM
12. IDS - Instrumentation/Data Subsystem		X	Secondary effects
13. D&C - Display and Control Subsystem		X	Secondary effects
14. C&W - Caution and Warning Subsystem		X	Secondary effects
15. Structure - CM & SM Secondary Structure Subsystem		X	Secondary effects
16. Crew Support Subsystem	X		Add equipment and supplies to support 56 days

TABLE I (Cont'd)

Subsystem	Major Mod	Minor Mod	Remarks
17. SLA - Spacecraft LM Adapter		X	No LM required for AAP-1, 3,3A
18. Stowage - Experiment data, resupply	X		Maximum stowage capability required
19. SCS - Stabilization & Control Subsystem			No modification required
20. EMS - Entry Monitor Subsystem			No modification required
21. CM RCS- CM Reaction Control Subsystem			No modification required
22. Heat Shield			No modification required
23. LES - Launch Escape Subsystem			No modification required
24. EIS - Earth Impact and Flota- tion Subsystem			No modification required
25. ERS - Earth Recovery Subsystem			No modification required
26. Docking Subsystem			No modification required

TABLE II  
CM/SM PRIMARY MODIFICATIONS VS MISSION REQUIREMENTS

<u>Mission Duration</u>	1. Two gas atmosphere 2. Long duration cryo storage 3. Long life fuel cells 4. SPS upgrading 5. RCS deorbit backup capability 6. Backup deorbit electrical power 7. Redundant battery charger 8. Change life limited pyro batteries
<u>Mission Support</u>	1. Command capability for LM/ATM unmanned rendezvous 2. RCS maneuver capability of cluster (PNGS & propellant budget) 3. Remote S-band antenna switching 4. Integrated C&W system 5. Cluster voice transmission to earth 6. Supply cluster atmosphere (cryo quantity) 7. Provide stowage provisions for cameras, data and resupply 8. Power transfer capability
<u>Docked Attitude Constraints</u>	1. Replumb ECS radiators 2. Increase CM glycol loop temperature 3. Add electrical heaters to cold biased components 4. Modify SM blanket insulation
<u>Weight &amp; Cost Savings</u>	1. SPS storage tank removal 2. High gain S-band antenna removal 3. One helium tank removed

## ATTACHMENT

AAP CM/SM MODIFICATIONS

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
EPS "Electrical Power Subsystem"	Three Block II P&W fuel cell power plants	Three uprated long life fuel cell assemblies	Fuel cell installation	Mission life - 14 days	Mission life - 56 days
	Two pyro batteries from the CM	One CM reentry battery (rechargeable) for pyro functions	Installation and wiring	Pyro batteries have an activation life of approx. 40 days. No in-flight charging capability	CM battery activation life requirements of 73 days (charging permissible)
	Return Battery Pack (SM)		Installation and wiring changes	Deorbit with loss of two fuel cells	Deorbit capability with loss of all 3 fuel cells
	Internal power transfer umbilical		Wiring and controls	Provide 180 watts of power to LM	Power transfer capability of 2000 watts in either direction with AM or LM/ATM power systems.
	Redundant CM battery charger		Battery charger switch	Single battery charger sufficient for 14-day mission	Redundant battery charger required for reliable 56-day capability
CSS "Cryogenic Storage Subsystem"	Block II O <sub>2</sub> and H <sub>2</sub> tanks and provisions	Seven 41.5" diameter cryo tanks	Plumbing, wiring, fill, vents, instrumentation, valves	O <sub>2</sub> Quantity - 640 lbs H <sub>2</sub> Quantity - 56 lbs Duration approx 30 days No N <sub>2</sub> capability	N <sub>2</sub> Quantity - 396 lbs O <sub>2</sub> Quantity - 3600 lbs H <sub>2</sub> Quantity - 225 lbs Duration - 56 days

Subsystem	Removed	Added	Modified	Block III Capability	AAP Requirements
ECS "Environmental Control Subsystem"		Water Sterilizer in CM		Bacteria control of water up to 14 days	Bacteria control of water up to 56 days
		Two gas $O_2/N_2$ system to control partial pressures and total pressure of atmosphere in the cluster	Increase flow rate capability of plumbing and regulator for cluster leakage	Single gas atmosphere	Two gas atmosphere required for missions greater than 30 days
		$N_2O_2$ internal umbilical to MDA for initial pressurization of cluster and EVA operations	Atmosphere control panel	Single gas low flow bleed capability for LM pressurization	CM/SM to supply high flow pressurization gasses to the AM, MDA and OWS and also provide high flow $O_2$ for EVA operations
		$O_2$ and $N_2$ heat ex-changers in the SM supplemented by electrical heaters	Redundant $O_2$ CM/SM umbilical replumbed for $N_2$ usage	No high flow capability for $O_2$ ; no $N_2$ capability	Command module requires $O_2$ and $N_2$ gas at a minimum of $45^{\circ}\text{F}$ for all flow conditions
		Intermodule atmosphere interchange duct and fan		CM control of $CO_2$ and moisture.	$CO_2$ and moisture removal is accomplished in the AM while the CM/SM is docked to the cluster. Atmosphere interchange is required

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
ECS (Cont'd)			Modify controls for CM coolant bypass loop to provide for 45°F or 60°F coolant loop temperatures	45°F coolant loop temperature only. Required for moisture removal	45°F coolant loop temperature required for flight mode. 60°F coolant loop temperature sufficient for docked mode. Requires less electrical power for the powered down condition and prevents equipment sweating
			Replumb ECS radiator to bypass small panels and permit isolation of one large panel	Radiator rejection requirement is 4000 to 8000 btu/hr with a spacecraft rotation	Radiator rejection requirement is 1500 to 6000 btu/hr with a constrained attitude
			Modify waste water dump to provide for manual dump capability	Automatic waste water dump	No dumping of contaminants during several experiment operations including ATM experiments
0.2 IVA Station for two men in the CM				No IVA support capability	IVA required to activate the AM systems after docking and pressurization
			Modify CM water system to interface with M487 water transfer vessels for OA operations	No water transfer capability	192 lbs of water required for experiments in the workshop. Provided from CM potable water system.

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
TCS "Thermal Control Subsystem"	Shadow shield on RCS external panel		Modify external RCS cork insulation	Prevent RCS engine burnthrough utilizing 1200 lbs of propellant. Maintain RCS tank temperature by SC rotation	Prevent RCS engine burnthrough utilizing 3600 lbs of RCS propellant. Maintain tank temperature in a fixed attitude
	Heaters for CM RCS, SM RCS, CM ECS, and SM SPS thermal control		SM superinsulation blankets tailored to configuration	CM/SM TCS designed for powered up, SC rotation and large SPS propellant heat sink	Provide CM/SM thermal control for powered down SC operation, fixed attitude and small SPS propellant heat sink
SECS "Sequence Events Control Subsystem"			Reconnect LM/SLA sequence controller to IU for AAP-4	LM separation controlled by CM/SM	LM/ATM separation for AAP-4 controlled by S-IVB TU
	Circuit provision for high gain antenna deployment			High gain antenna deployment required	SM high gain antenna removed (see communications subsystem)
Pyrotechnic Subsystem					Empty SLA, no LM requirement

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
LV EDS "Emergency Detection Subsystem	5 engine out light display panel	8 engine out light display panel		Saturn V launch vehicle (5 engine)	Saturn I launch vehicle (8 engine)
PNGS "Primary Navigation and Guidance Subsystem			Software mod to CMC rope memory	Software designed for specific Apollo mission	Software designed to support AAP missions
		Data entry and display (DEDA); Command console; translation hand controller. (AAP 3 only)	Rendezvous and docking is accomplished by manned operation	The CM G&C is required to provide the capability of generating commands to the LM/ATM to support unmanned rendezvous and docking	
SPS "Service Propulsion Subsystem	Fuel and oxidizer storage tanks with associated plumbing and gaging systems	Propellant plumbing	Block II requires approximately 40,000 pounds of SPS propellant	1)Missions defined, including 2-1/2 stages to orbit, require approx. 20,000 lbs of SPS propellant. Capacity of sump tank is 21,600 lbs. 2)Additional SM volume required for added cryo tanks.	
	One of two helium tanks	Pressurization plumbing	Two tanks required for 40,000 lbs of propellant	One tank required for 20,000 lbs of propellant. Weight savings.	

<u>Subsystem</u>	<u>Removed</u>	<u>Added</u>	<u>Modified</u>	<u>Block II Capability</u>	<u>AAP Requirements</u>
<u>SPS (Cont'd)</u>		Pressure Volume Temperature (PVT) propellant leak detection system		No SPS leak detection requirement. Gaging of propellants accom- plished under thrust- ing conditions	Provide a method of detecting propellant system leaks during long inactive periods i.e., 56 days.
		Series redundant fuel and oxidizer check valves		Single fuel and oxi- dizer check valves adequate for 14-day mission	Prevent pressurant supply contamination by propellants for 56 days
		Series redundant $N_2$ pressure regu- lator in engine valve system		Single $N_2$ pressure regulation adequate for 14 day mission	Provide reliable $N_2$ regulation for engine valve system
<u>CM RCS</u> "Reaction Control Sub- system"				Provide CM attitude control and rate damping after SM separation	Provide CM attitude control and rate damping after SM separation
<u>SM RCS</u>	Redundant helium supply flow path on quads		Replumb existing RCS quads to com- mon manifolds	No interconnection of quads	Sequential depletion of quad doors required for propellant con- servation and thermal considerations
		Four RCS propellant subsystems (600 lbs capacity each)		1200 lbs of propel- lant	3600 lbs of propellant; included is 1200 lbs to satisfy backup de- orbit requirement

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
SM RCS (Cont'd)				Quads depleted simultaneously	Sequential depletion of Block II quads and added modules required for thermal considerations, fuel conservation, isolation capability and general propellant management. Automatic feature for safety of flight.
	Interconnection manifold. Automatic module electrical switching unit with manual backup (sequential module depletion)			No propellant accumulators	Manifolding of RCS propellants requires accumulators to prevent excessive propellant pressure fluctuations.
	Propellant manifold accumulators			S-band communication maintained at lunar distances	High gain antenna not required in earth orbit
CS Communication Subsystem	High gain antenna and associated equipment			Modify S-band omni antenna switch panel to accept OA commands	S-band antennas are manually switched in the CM
					Ground switching of CM/SM S-band omni antenna through the AM up-data link to maintain communications without crew participation
	Interface wiring, intercom box, power control switch (audio system)			Control panel switch for integrated audio system	Provide capability of transmitting audio from all modules via the CM communication systems and interconnect module audio systems

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
CS (Cont'd)		2 VHF/FM Transmitters and switches (AAP-3 only)	VHF triplexer channel to be modified to accept new frequency (AAP-3 only)	No VHF/FM command capability	System required to transmit G&C commands to LM/ATM for unmanned rendezvous and docking
IDS "Instrumentation Data Subsystem"			Instrumentation cable modifications	Instrumentation cable peculiar to Block II	Modifications to subsystems require measurements to be changed and added.
D&C "Display & Control"		Circuit breaker panels in lower equipment bay Power umbilical panel Fuel cell start up panel Thermal management control panel Command console panel	Modify nomenclature and/or display on 5 of the 62 Block II D&C Panels.		D&C panel to support new and modified subsystem requirements
C&W "Caution and Warning"		Cluster unit Klixon warning Sleep switch override	Detection units Comparators Display matrices Interface wiring	CM and LM C&W systems are separate	Integrate all module caution and warning systems into a cluster C&W system
Structural Subsystem "CM & SM"	CM and SM secondary structure which supports deleted hardware	CM & SM structure to support new hardware	CM and SM secondary structure to support modified hardware	As Designed	Modify secondary structure as required to support modifications
Crew Support Subsystem	Food, Medical Supplies, Personal Hygiene, Garments, Data.	Pressure Garment Assemblies (PGA)	14-day support for 3 crewmen	56-day support for 3 crewmen including EVA	

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
CM Launch Stowage and Return Payload		Stowage compartments on the aft bulkhead	Reconfigure existing stowage	Limited stowage capa- bility. 14 day mission. Minimum experiment re- turn	Experiment resupply, 56 day crew provision- ing, experiment data return including ATM cameras and film
SLA "Spacecraft LM Adapter"	LM Separation sequence controller LM tie down link and pyros Lower umbilical guillotine	Stabilizing device		CM/SM controls the LM/SLA separation	No LM requirements
LES "Launch Escape Subsystem"				CM abort capability below 100,000 ft	CM abort below 100,000 ft
ERS "Earth Recovery Subsystem"				Decelerate and land safely a 13,000 lb spacecraft	Decelerate and land safely a 13,000 lb spacecraft
Heat Shield				Designed to withstand transearth reentry	Withstand earth orbit reentry (less severe than transearth)
SCS "Stabilization and Control Subsystem"				Provides for manual operation of RCS and SPS subsystem	Manual control of RCS and SPS subsystems

10.

Subsystem	Removed	Added	Modified	Block II Capability	AAP Requirements
EMS "Entry Monitor Subsystem"				Provides data for safe manual reentry	Provide data for safe manual reentry
Docking Subsystem "Probe"				Provides coupling and separating the CM and LM	Provide coupling and separating the CM and LM and also the MDA. (Both have identical drogue assemblies.)
EIS "Earth Impact and Flotation"				Provides land landing impact arresting within specified limits and safe water landing with flotation and stability	Provides land landing impact arresting within specified limits and safe water landing with flotation and stability

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